

AFRRRI SR71-16  
NOVEMBER 1971

**AFRRRI**  
**SCIENTIFIC**  
**REPORT**

**NOREPINEPHRINE EFFECTS  
ON EARLY POSTIRRADIATION  
PERFORMANCE DECREMENT  
IN THE MONKEY**

**J. E. Turns  
T. F. Doyle  
C. R. Curran**

**ARMED FORCES RADIobiology RESEARCH INSTITUTE  
Defense Nuclear Agency  
Bethesda, Maryland**

All aspects of investigative programs involving the use of laboratory animals sponsored by DoD components are conducted according to the principles enunciated in the "Guide for Laboratory Animal Facilities and Care", prepared by the National Academy of Sciences - National Research Council.

NOREPINEPHRINE EFFECTS ON EARLY POSTIRRADIATION  
PERFORMANCE DECREMENT IN THE MONKEY

J. E. TURNS  
T. F. DOYLE  
C. R. CURRAN

*R. E. George*  
R. E. GEORGE  
Commander, MSC, USN  
Chairman  
Radiation Biology Department

*W. F. Davis, Jr.*  
W. F. DAVIS, JR.  
Chairman  
Behavioral Sciences Department

*Myron I. Varon*  
MYRON I. VARON  
Captain MC USN  
Director

ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE  
Defense Nuclear Agency  
Bethesda, Maryland

#### ACKNOWLEDGMENT

The authors wish to acknowledge the technical assistance of R. L. Brubaker, W. G. Ewald and C. G. Franz.

## TABLE OF CONTENTS

	Page
Foreword (Nontechnical summary) . . . . .	iii
Abstract . . . . .	v
I. Introduction . . . . .	1
II. Methods and Materials . . . . .	1
III. Results . . . . .	3
IV. Discussion . . . . .	8
V. Conclusion . . . . .	9
References . . . . .	10

## LIST OF FIGURES

Figure 1. Average mean arterial blood pressure of monkeys infused with isotonic saline or norepinephrine following 4000 rads of mixed gamma-neutron radiation . . . . .	3
Figure 2. Mean arterial pressure, performance, and isotonic saline infusion rate of monkeys irradiated with 4000 rads of mixed gamma-neutron radiation . . . . .	4-5
Figure 3. Mean arterial pressure, performance, and norepinephrine infusion rate of monkeys irradiated with 4000 rads of mixed gamma-neutron radiation . . . . .	6-7
Figure 4. Average performance of monkeys infused with isotonic saline or norepinephrine following 4000 rads of mixed gamma-neutron radiation . . . . .	8

FOREWORD  
(Nontechnical summary)

Four thousand rads of pulsed mixed gamma-neutron radiation usually cause monkeys to be temporarily unable to perform a learned task. This early transient incapacitation is accompanied by a severe drop in blood pressure. The currently reported experiment was designed to determine whether the prevention of low blood pressure by intravenous infusion of norepinephrine, a vasoconstrictor, would have a beneficial effect on the postirradiation performance of monkeys.

Twenty male monkeys were trained to perform a task which consisted of moving a lever associated with a stimulus light. Each of the animals was then given 4000 rads of mixed gamma-neutron radiation and its blood pressure and ability to perform the learned task were measured. Ten of the monkeys were treated with a postirradiation intravenous infusion of norepinephrine to prevent the usual severe drop in blood pressure; the other ten trained monkeys were used as controls and given a postirradiation infusion of isotonic saline.

Postirradiation performance of the animals was frequently below satisfactory levels during periods of severe hypotension. However, there were also numerous occasions when the blood pressure was considered adequate (at least 60 percent of preirradiation values) but performance was quite poor. Apparently inadequate blood pressure is a limiting factor in the capacity to perform, but adequate blood pressure is not a guaranty of good performance.

Norepinephrine effectively maintained the blood pressure of eight of ten monkeys. When the average blood pressure of the treated animals was compared with the

average of the ten saline-treated controls, there was a significant difference. However, there was no statistically significant difference between the average performance of these two groups.

## ABSTRACT

Monkeys, trained to perform a discrete trial, cued avoidance task, were used to measure the effectiveness of intravenously infused norepinephrine in preventing the hypotension and performance decrement which usually follows 3000- to 30,000-rad doses of radiation. After a 4000-rad dose of mixed gamma-neutron radiation, 10 animals were infused with norepinephrine at a rate designed to maintain mean arterial blood pressure at approximately 100 mm Hg; for comparison 10 control animals were infused with only isotonic saline after similar irradiation. Norepinephrine, although generally adequate for maintaining blood pressure, did not consistently improve performance during the first 30 minutes postirradiation.

## I. INTRODUCTION

Following supralethal doses of ionizing radiation, in the range of 3000-30,000 rads, monkeys usually experience a partial or complete inability to perform a learned task. This early incapacitation is characteristically transient and is followed by a temporary recovery to normal or near normal levels of performance; this, in turn, is followed by severe performance decrement and death.<sup>7-9</sup>

The period of early transient incapacitation (ETI) is preceded or accompanied by hypotension, and a causal relationship has been suggested.<sup>1</sup> An earlier study of untrained monkeys whose postirradiation blood pressures were maintained by norepinephrine or other pressor drugs showed that as long as the arterial pressure remained above a critical level of approximately 60 percent of preirradiation pressure, the monkeys remained conscious and appeared alert.<sup>5</sup> However, no measurements were made of the monkeys' ability to perform a learned task. The present study evaluates the effect of norepinephrine on the ability of monkeys to perform a learned task after 4000 rads of mixed gamma-neutron radiation.

## II. METHODS AND MATERIALS

Twenty male Macaca mulatta, 2 to 3 years old and weighing 3 to 4 kg, were used. Each animal had femoral arterial and venous catheters surgically implanted 3 days before irradiation.

Each monkey was trained to perform a discrete trial, cued avoidance task which consisted of moving one of two levers, each associated with a single stimulus light. A trial consisted of a stimulus light being lit for 5 seconds, accompanied by a warning tone during the 1st second. If the animal operated the lever associated with the light,

the light was extinguished and the trial ended. If the animal failed to move the correct lever within 5 seconds, it received a 1/2-second electrical shock. Ten seconds elapsed between the start of one trial and the start of the next. Light cues were presented in random order an equal number of times within blocks of 100 trials except that no lever was cued correct consecutively for more than three trials. One hundred trial sessions were separated by a 5-minute rest period.

Each animal was trained until it had performed 2000 trials (400 trials per day) at the criterion level of 90 percent or more correct. Total training time averaged 21 days.

One day before irradiation the monkey was tested for 2 hours to establish a base line, and on the day of irradiation each animal was positioned in the exposure room and given a 100-trial test to insure that a criterion level of performance was maintained. All animals were tested for a maximum of 120 minutes following irradiation.

Each animal received a  $4000 \pm 400$ -rad midline tissue dose of mixed gamma-neutron radiation delivered as a short duration pulse (approximately 25 milliseconds, pulse width at half maximum height).

Arterial blood pressure was monitored\* and at the moment of irradiation an infusion pump† was turned on. In 10 of the animals the rate of infusion was automatically controlled‡ to infuse norepinephrine§ (1 mg/ml) at a linearly increasing rate with decreasing blood pressure from 100 mm Hg to 50 mm Hg; maximum infusion rate (1.23 ml/min) occurred when the arterial pressure was 50 mm Hg or less. The norepinephrine infusion was maintained, as needed, until the end of the testing period.

\* Pressure transducer, Type P23Db, Statham Laboratories Inc., Hato Rey, Puerto Rico

† Infusion pump, Harvard Apparatus Company, Millis, Massachusetts

‡ Servo Control Amplifier, Harvard Apparatus Company, Millis, Massachusetts

§ Levophed brand of levarterenol, Winthrop Laboratories, New York, N. Y.

The 10 control animals were infused with isotonic saline at a rate of 1.23 ml/min for the 1st minute following irradiation, nine-tenths of this rate for the 2nd minute, eight-tenths for the 3rd minute, and so on for a total of about 7 ml of saline.

Mean arterial blood pressure (MAP) was calculated as diastolic pressure plus one-third of pulse pressure. The "critical level" of MAP is defined as 60 percent of preirradiation pressure. Severe performance decrement is defined here as less than 50 percent correct responses in a given block of 100 trials.

Student's "t" test was used to test the significance of group mean data; p values less than 0.05 were considered significant.

### III. RESULTS

Typical of monkeys receiving a 4000-rad dose of radiation, severe hypotension generally occurred very soon after irradiation in the saline-treated animals (Figures 1 and 2). In most instances the hypotension was accompanied or followed by a period of

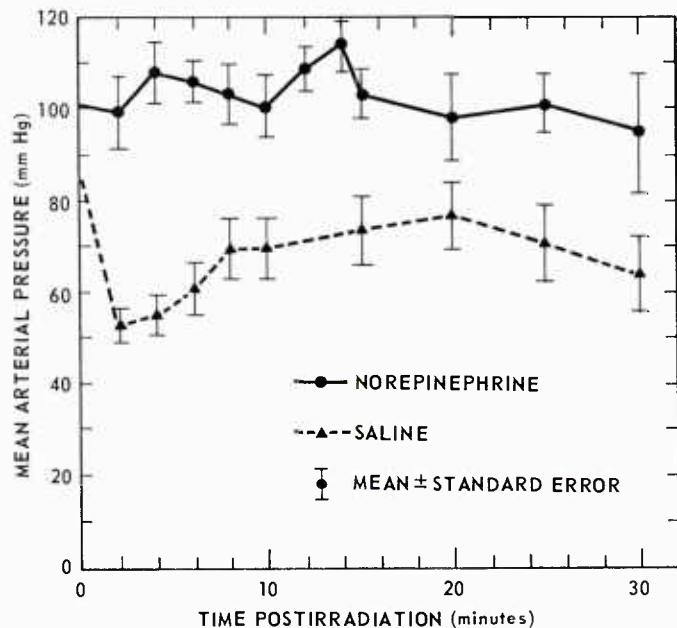


Figure 1. Average mean arterial blood pressure of monkeys infused with isotonic saline or norepinephrine following 4000 rads of mixed gamma-neutron radiation. Each group was composed of 10 animals.

performance decrement of at least moderate severity (less than 75 percent correct responses). Blood pressures of the norepinephrine-treated animals generally remained near preirradiation values; however, at least moderately severe performance decrement occurred in six of these ten animals within 4 minutes postirradiation

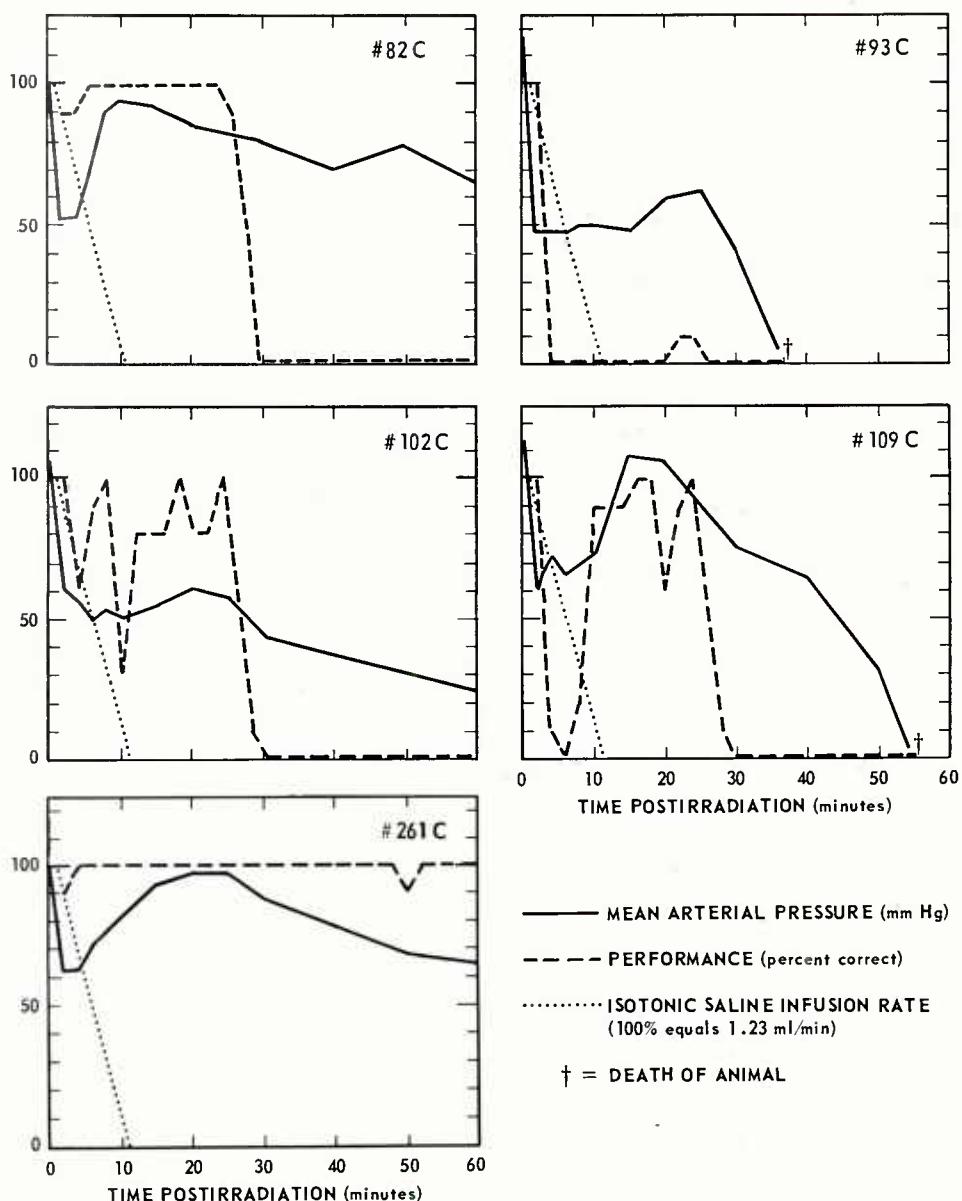


Figure 2. Mean arterial pressure, performance, and isotonic saline infusion rate of monkeys irradiated with 4000 rads of mixed gamma-neutron radiation

(Figures 1 and 3). The difference between the average performance of the two groups of monkeys was not significant at any time during the first 30 minutes postirradiation (Figure 4).

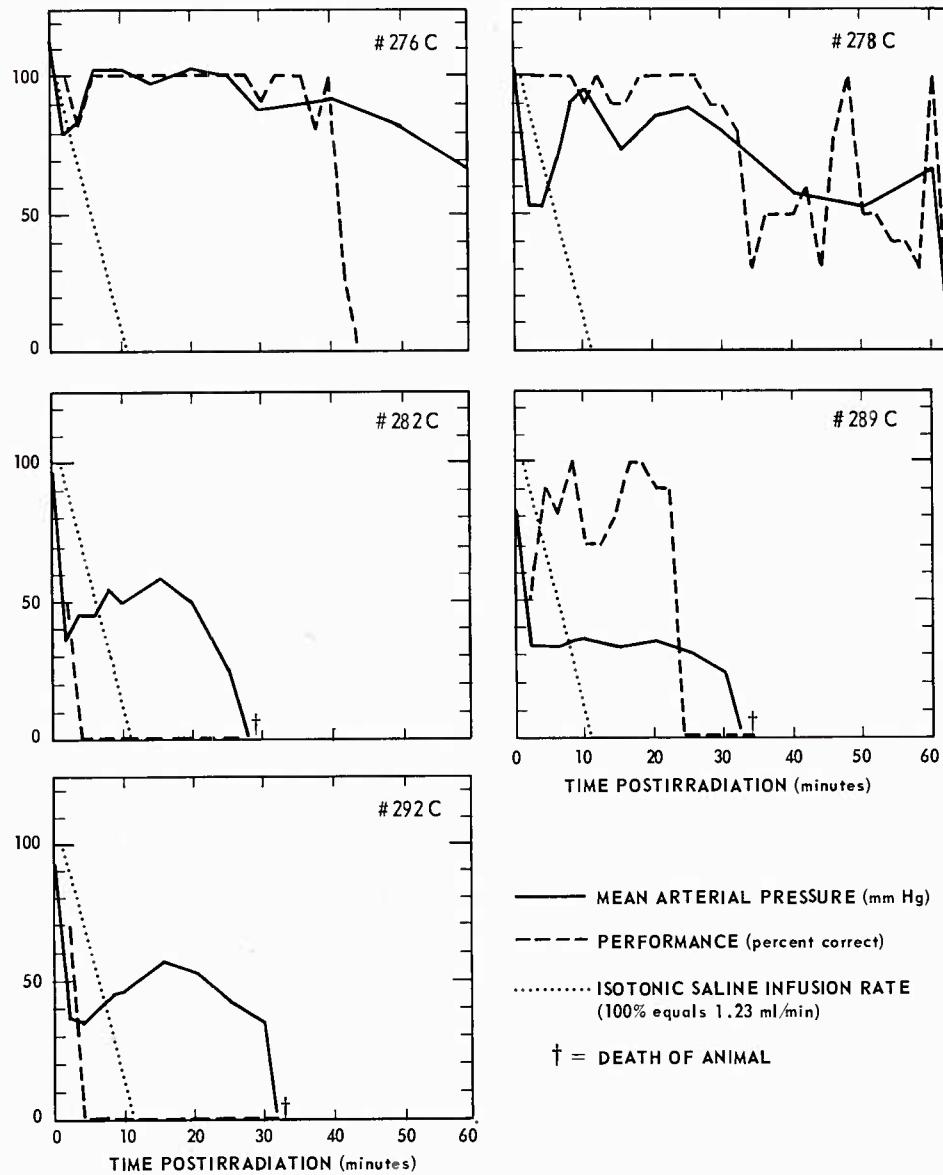


Figure 2 (continued)

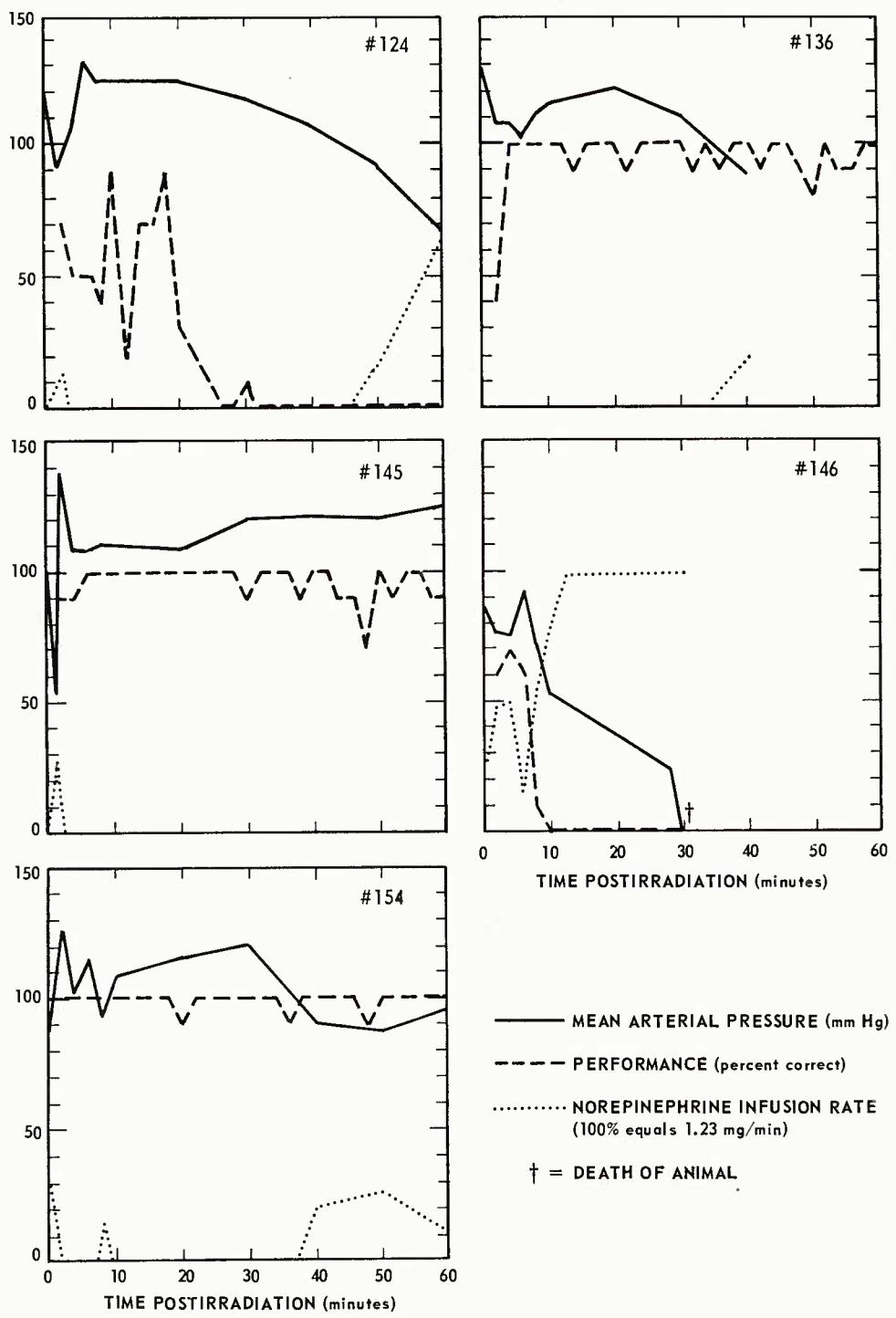


Figure 3. Mean arterial pressure, performance, and norepinephrine infusion rate of monkeys irradiated with 4000 rads of mixed gamma-neutron radiation

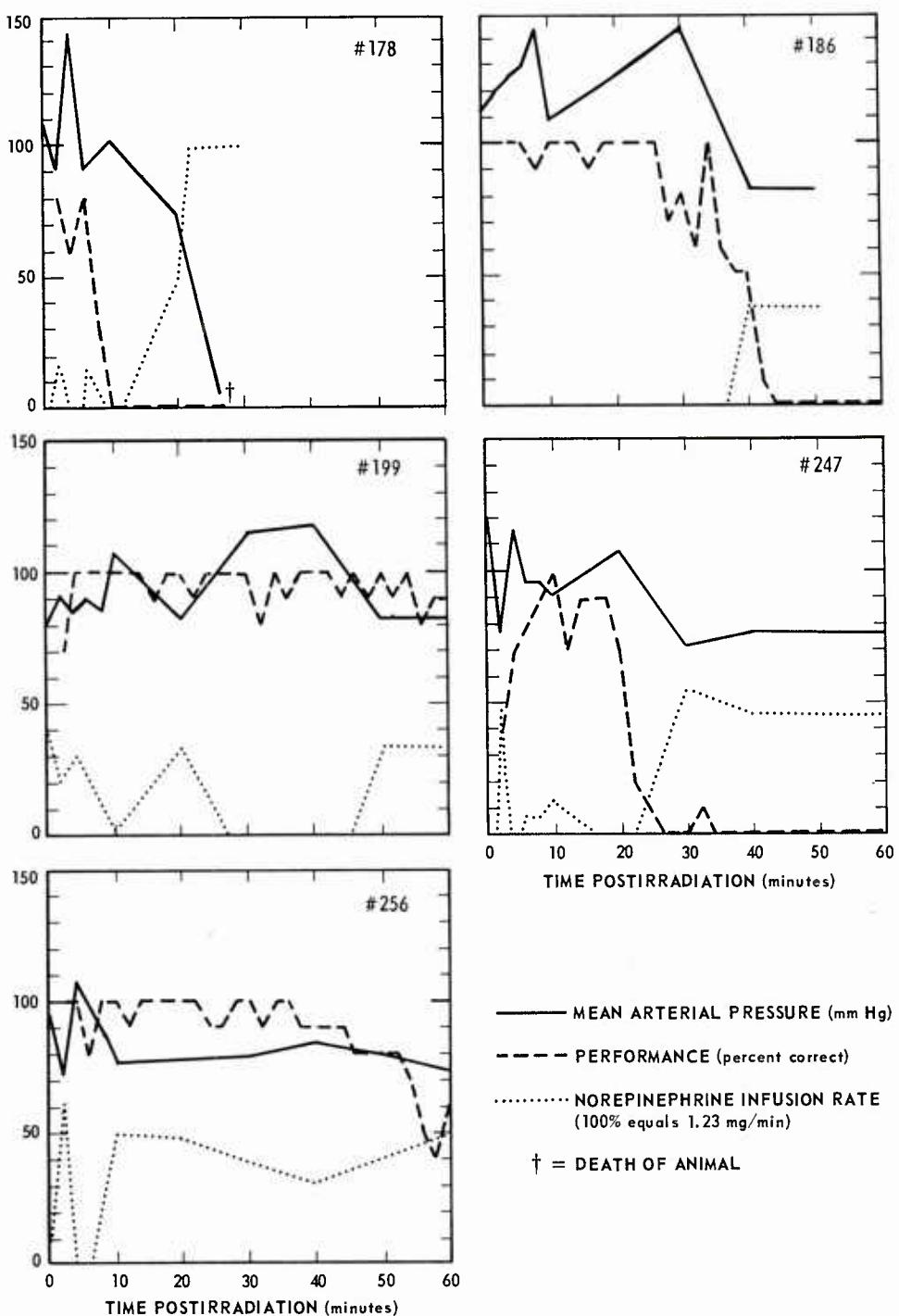


Figure 3 (continued)

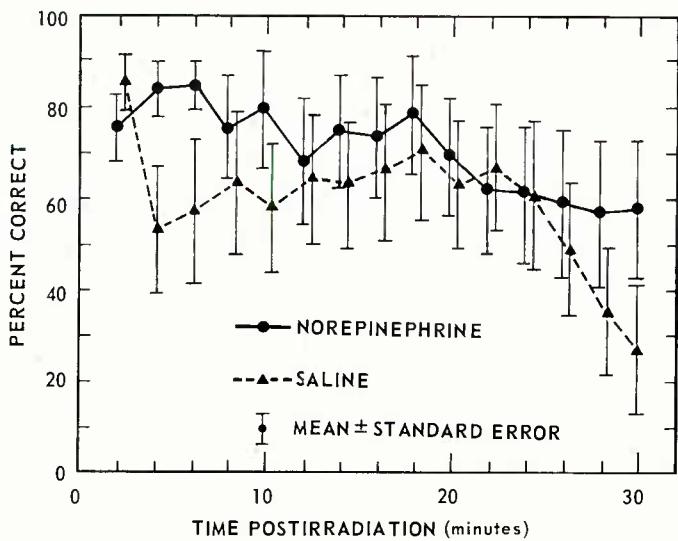


Figure 4. Average performance of monkeys infused with isotonic saline or norepinephrine following 4000 rads of mixed gamma-neutron radiation. Each group was composed of 10 animals.

Severe performance decrement, less than 50 percent correct responses, occurred in six of the treated animals (124, 136, 146, 178, 186, and 247) during periods when blood pressure was considered to be within acceptable limits, i.e., above 60 percent of preirradiation values (Figure 3).

One of the control animals, 289C, continued to perform at or above 70 percent correct from 4 to 22 minutes postirradiation while its mean arterial pressure was only about 40 percent of preirradiation values.

The mean survival time of the norepinephrine-treated animals ( $9 \pm 4.5$  hours) did not differ significantly from that of the control animals ( $20 \pm 13$  hours).

#### IV. DISCUSSION

Important factors in the maintenance of consciousness are adequate cerebral blood flow and cerebral oxygen consumption.<sup>2</sup> In man, cerebral circulation is relatively unaffected by blood pressure until the blood pressure falls below a critical level

of approximately 50 to 60 percent of normal mean arterial pressure. Blood pressures below this level diminish cerebral blood flow enough to cause clinical signs of cerebral hypoxia; loss of consciousness, or incapacitation, correlates roughly with decreased oxygen consumption.<sup>4</sup>

In normotensive individuals, norepinephrine moderately reduces cerebral blood flow by increasing cerebral resistance;<sup>2</sup> however, during hypotension, norepinephrine increases blood pressure proportionately more than cerebral resistance is increased resulting in a net increase of cerebral blood flow.<sup>6</sup>

The adverse effects of norepinephrine must also be considered. In the presence of exogenous norepinephrine, cardiac and cerebral blood flows are maintained at the expense of splanchnic and skeletal circulation and, if this state is sufficiently prolonged, ischemia, anoxia, tissue necrosis and lethal shock develop.<sup>3</sup> In the present study, the deleterious effect of norepinephrine appeared evident in that the survival time of the treated subjects was reduced when compared to that of the control animals.

Norepinephrine was generally effective in maintaining the blood pressure of the monkey for some time after irradiation; however, the difference in postirradiation performance between the norepinephrine- and saline-treated animals was not statistically significant at any time.

## V. CONCLUSION

Norepinephrine, while effective in maintaining postirradiation blood pressure, is ineffective in preventing a performance decrement following irradiation. Severe hypotension may be a limiting factor to the maintenance of adequate performance post-irradiation; however, radiation-induced performance decrement can occur even when blood pressure levels are well above what have been considered critical levels.

## REFERENCES

1. Chapman, P. H. and Young, R. J. Effect of cobalt-60 gamma irradiation on blood pressure and cerebral blood flow in the Macaca mulatta. Radiation Res. 35:78-85, 1968.
2. King, B. D., Sokoloff, L. and Wechsler, R. L. The effects of 1-nor-epinephrine upon cerebral circulation and metabolism in man. J. Clin. Invest. 31:273-279, 1952.
3. Lansing, A. M. and Stevenson, J. A. F. Mechanism of action of norepinephrine in hemorrhagic shock. Am. J. Physiol. 193:289-293, 1958.
4. Lassen, N. A. Cerebral blood flow and oxygen consumption in man. Physiol. Rev. 39:183-238, 1959.
5. Miletich, D. J. and Strike, T. A. Alteration of postirradiation hypotension and incapacitation in the monkey by administration of vasopressor drugs. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR70-1, 1970.
6. Moyer, J. H., Morris, G. and Smith, C. P. Cerebral hemodynamics during controlled hypotension induced by the continuous infusion of ganglionic blocking agents (hexamethonium, Pendiomide and Arfonad). J. Clin. Invest. 33:1081-1088, 1954.
7. Rice, E. A. Early performance decrement in primates following pulsed ionizing radiation. Brooks Air Force Base, Texas, U. S. Air Force School of Aerospace Medicine Report TR65-60, 1965.
8. Seigneur, L. J. and Brennan, J. T. Incapacitation in the monkey (Macaca mulatta) following exposure to a pulse of reactor radiations. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR66-2, 1966.
9. Thorp, J. W. and Young, R. W. Monkey performance after partial body irradiation: dose relationships. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR70-11, 1970.

DISTRIBUTION LIST

AIR FORCE

The Surgeon General, U. S. Department of the Air Force, Washington, D. C. 20314 (1)  
Executive Officer, Director of Professional Services, Office of the Surgeon General, Hq. USAF (AFMSPA),  
Washington, D. C. 20314 (1)  
Headquarters, U. S. Air Force (AFMSPAB), Washington, D. C. 20314 (1)  
Office of the Command Surgeon (ADCSG), Hq. ADC, USAF, Ent AFB, Colorado 80912 (1)  
Air Force Weapons Laboratory, ATTN: WLIL (1), ATTN: WLRB-2 (1), Kirtland AFB, New Mexico 87117 (2)  
Chief, Nuclear Medicine Department, P. O. Box 5088, USAF Hospital, Wright-Patterson AFB, Ohio 45433 (1)  
USAFSAM (RA), ATTN: Chief, Radiobiology Division, Brooks AFB, Texas 78235 (1)  
USAFSAM, ATTN: EDAD, Brooks AFB, Texas 78235 (1)

ARMY

The Surgeon General, U. S. Department of the Army, Washington, D. C. 20314 (1)  
Surgeon General, ATTN: MEDDH-N, U. S. Department of the Army, Washington, D. C. 20314 (1)  
USAACDC CSSG, Doctrine Division, Fort Lee, Virginia 23801 (1)  
Commanding Officer, USAACDC CBR Agency, Fort McClellan, Alabama 36201 (1)  
Commanding Officer, U. S. Army Combat Developments Command, Institute of Nuclear Studies, Fort Bliss, Texas 79916 (1)  
CG, USCONARC, ATTN: ATUTR-TNG (NBC), Fort Monroe, Virginia 23351 (1)  
Nuclear Branch AMCRD-DN-RE, U. S. Army Materiel Command, Washington, D. C. 20315 (1)  
Commanding Officer, U. S. Army Medical Research Laboratory, Fort Knox, Kentucky 40121 (1)  
Commanding Officer, USA Nuclear Medical Research Detachment, Europe, APO New York, N. Y. 09180 (2)  
Chief of Research and Development, ATTN: Nuclear, Chemical and Biological Division, U. S. Department of the Army, Washington, D. C. 20310 (1)  
Army Research Office, ATTN: Chief, Scientific Analysis Branch, Life Sciences Division, 3045 Columbia Pike, Arlington, Virginia 22204 (1)  
Division of Nuclear Medicine, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, D. C. 20012 (5)  
Commanding Officer, U. S. Army Environmental Hygiene Agency, ATTN: USAEHA-RP, Edgewood Arsenal, Maryland 21010 (1)  
Commandant, U. S. Army Medical Field Service School, ATTN: MEDEW-ZNW, Fort Sam Houston, Texas 78234 (1)

NAVY

Chief, Bureau of Medicine and Surgery, U. S. Navy Department, Washington, D. C. 20390 (1)  
Chief, Bureau of Medicine and Surgery, ATTN: Code 71, U. S. Navy Department, Washington, D. C. 20390 (1)  
Commanding Officer, Naval Aerospace Medical Institute, Naval Aviation Medical Center, ATTN: Director of Research, Pensacola, Florida 32512 (3)  
Commanding Officer, Nuclear Weapons Training Center, Atlantic, Nuclear Warfare Department, Norfolk, Virginia 23511 (1)  
Commanding Officer, Nuclear Weapons Training Center, Pacific, U. S. Naval Air Station, North Island, San Diego, California 92135 (1)  
Director, Biological Sciences Division, Office of Naval Research, Washington, D. C. 20360 (1)  
Commanding Officer, U. S. Naval Hospital, ATTN: Director, REEL, National Naval Medical Center, Bethesda, Maryland 20014 (1)  
Head, Animal Behavioral Sciences Branch, Naval Aerospace Medical Institute, Naval Aerospace Medical Center, ATTN: Dr. John S. Thach, Jr., Pensacola, Florida 32512 (1)  
Commanding Officer, Naval Submarine Medical Center, Naval Submarine Base, NL, ATTN: Medical Library, Groton, Connecticut 06340 (1)  
Commanding Officer, Naval Submarine Medical Center, Naval Submarine Base, NL, ATTN: Code 53, Nuclear Medicine Training Division, Groton, Connecticut 06340 (1)

D.O.D.

Director, Defense Nuclear Agency, Washington, D. C. 20305 (1)  
Director, Defense Nuclear Agency, ATTN: DDST, Washington, D. C. 20305 (1)  
Director, Defense Nuclear Agency, ATTN: Chief, Medical Directorate, Washington, D. C. 20305 (4)  
Director, Defense Nuclear Agency, ATTN: Chief, Radiation Directorate, Washington, D. C. 20305 (1)

D. O. D. (continued)

Director, Defense Nuclear Agency, ATTN: Technical Library (APTL), Washington, D. C. 20305 (2)  
Commanding Officer, Harry Diamond Laboratories, ATTN: Nuclear Vulnerability Branch, Washington, D. C. 20438 (1)  
Commander, Field Command, Defense Nuclear Agency, ATTN: FC Technical Library, Kirtland AFB, New Mexico 87117 (1)  
Commander, Headquarters Field Command, Defense Nuclear Agency, ATTN: FCTG8, Kirtland AFB, New Mexico 87117 (2)  
Director, Armed Forces Institute of Pathology, Washington, D. C. 20305 (1)  
Administrator, Defense Documentation Center, Cameron Station, Bldg. 5, Alexandria, Virginia 22314 (12)

OTHER GOVERNMENT

U. S. Atomic Energy Commission, Headquarters Library, Reports Section, Mail Station G-17, Washington, D. C. 20545 (1)  
U. S. Atomic Energy Commission, Division of Biology and Medicine, Washington, D. C. 20545 (1)  
U. S. Atomic Energy Commission, Bethesda Technical Library, 7920 Norfolk Avenue, Bethesda, Maryland 20014 (1)  
National Aeronautics and Space Administration, Manned Spacecraft Center, ATTN: Dr. Charles M. Barnes, Code DC7, Houston, Texas 77058 (1)  
National Aeronautics and Space Administration, Manned Spacecraft Center, ATTN: Dr. B. D. Newsom, Code DB4, Houston, Texas 77058 (1)  
National Bureau of Standards, ATTN: Chief, Radiation Physics Division, Washington, D. C. 20234 (1)  
U. S. Public Health Service, Bureau of Radiological Health, Division of Biological Effects, 12720 Twinbrook Parkway, Rockville, Maryland 20852 (1)  
U. S. Public Health Service, Bureau of Radiological Health, Library, 12720 Twinbrook Parkway, Rockville, Maryland 20852 (1)  
U. S. Public Health Service, Northeastern Radiological Health Laboratory, 109 Holton Street, Winchester, Massachusetts 01890 (1)  
U. S. Public Health Service, Southeastern Radiological Health Laboratory, P. O. Box 61, Montgomery, Alabama 36101 (1)  
U. S. Public Health Service, Southwestern Radiological Health Laboratory, P. O. Box 15027, Las Vegas, Nevada 89114 (1)

OTHER

Argonne National Laboratory, Library Services Department, Report Section Bldg. 203, RM-CE-125, 9700 South Cass Avenue, Argonne, Illinois 60440 (1)  
Dr. Donald G. Baker, Radiobiology Department, Zellerbach Saroni Tumor Institute, 1600 Divisadero Street, San Francisco, California 94115 (1)  
Dr. J. T. Brennan, Radiology Department, University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pennsylvania 19104 (1)  
Brookhaven National Laboratory, Information Division, ATTN: Research Library, Upton, Long Island, New York 11973 (2)  
Dr. J. S. Burkle, Director of Nuclear Medicine, York Hospital, York, Pennsylvania 17403 (1)  
S. C. Bushong, Department of Radiology, Baylor University College of Medicine, Houston, Texas 77024 (1)  
University of California, Lawrence Radiation Laboratory, Library, Bldg. 50, Room 134, Berkeley, California 94720 (1)  
Director, Radiobiology Laboratory, University of California, Davis, California 95616 (1)  
University of California, Lawrence Radiation Laboratory, Technical Information Division Library L-3, P. O. Box 808, Livermore, California 94551 (2)  
University of California, Laboratory of Nuclear Medicine and Radiation Biology, Library, 900 Veteran Avenue, Los Angeles, California 90024 (1)  
Dr. C. Jelleff Carr, Director, Life Sciences Research Office, Federation of American Societies for Experimental Biology, 9650 Rockville Pike, Bethesda, Maryland 20014 (1)  
Cdr. William H. Chapman, USN (Ret.), Bio-Medical Division L-523, Lawrence Radiation Laboratory, University of California, P. O. Box 808, Livermore, California 94551 (1)  
Director, Collaborative Radiological Health Laboratory, Colorado State University, Fort Collins, Colorado 80521 (1)  
Dr. L. W. Davis, Radiology Department, University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pennsylvania 19104 (1)  
Professor Merril Eisenbud, New York University, Tuxedo, New York 10987 (1)  
Dr. T. C. Evans, Radiation Research Laboratory, College of Medicine, University of Iowa, Iowa City, Iowa 52240 (1)

OTHER (continued)

Dr. Arnold Feldman, Institute of Radiology, School of Medicine, Washington University, 510 South Kingshighway, St. Louis, Missouri 63110 (1)

Mr. Orin Gelderloos, Division of Literature, University of Michigan, Dearborn Campus, Dearborn, Michigan 48124 (1)

General Dynamics/Fort Worth, ATTN: Librarian, P. O. Box 748, Fort Worth, Texas 76101 (1)

Gulf General Atomic Incorporated, ATTN: Library, P. O. Box 608, San Diego, California 92112 (1)

Dr. James E. Huff, Department of Pharmacology and Toxicology, School of Medicine and Dentistry, University of Rochester, 260 Crittenden Blvd., Rochester, New York 14620 (1)

IIT Research Institute, ATTN: Document Library, 10 West 35th Street, Chicago, Illinois 60616 (1)

Johns Hopkins University, Applied Physics Laboratory, ATTN: Document Library, 8621 Georgia Avenue, Silver Spring, Maryland 20910 (1)

Dr. R. F. Kallman, Department of Radiology, Stanford University, Palo Alto, California 94305 (1)

Dr. L. S. Kelly, Donner Laboratory, University of California at Berkeley, Berkeley, California 94720 (1)

Dr. Robert Landolt, Bionucleonics Department, Purdue University, Lafayette, Indiana 47907 (1)

Los Alamos Scientific Laboratory, ATTN: Report Librarian, P. O. Box 1663, Los Alamos, New Mexico 87544 (1)

Director, Nuclear Science Center, Louisiana State University, Baton Rouge, Louisiana 70803 (2)

Lovelace Foundation for Medical Education and Research, Document Library, 5200 Gibson Blvd., S. E., Albuquerque, New Mexico 87108 (1)

Dr. Ross A. McFarland, Guggenheim Professor of Aerospace Health and Safety, Harvard School of Public Health, 665 Huntington Avenue, Boston, Massachusetts 02115 (1)

Dr. J. I. Marcum, Rand Corporation, 1700 Main Street, Santa Monica, California 90401 (1)

Massachusetts Institute of Technology, M.I.T. Libraries, Technical Reports, Room 14 E-210, Cambridge, Massachusetts 02139 (1)

Dr. Charles W. Mays, Physics Group Leader, Radiobiology Division, University of Utah, Salt Lake City, Utah 84112 (1)

Ohio State University, Nuclear Reactor Laboratory, 1298 Kinnear Road, Columbus, Ohio 43212 (1)

Dr. Harvey M. Patt, Laboratory of Radiobiology, University of California, San Francisco Medical Center, San Francisco, California 94122 (1)

Purdue University, Nuclear Engineering Library, Lafayette, Indiana 47907 (1)

Dr. S. M. Reichard, Director, Division of Radiobiology, Medical College of Georgia, Augusta, Georgia 30902 (1)

Dr. H. H. Rossi, 630 West 168th Street, New York, N. Y. 10032 (1)

Dr. Eugene L. Saenger, Director, Radioisotope Laboratory, Cincinnati General Hospital, Cincinnati, Ohio 45229 (1)

Sandia Corporation Library, P. O. Box 5800, Albuquerque, New Mexico 87115 (1)

Scientific Committee on the Effects of Atomic Radiation, ATTN: Library, United Nations Room 3267, United Nations Plaza, New York, N. Y. 10017 (1)

Scope Publications, Franklin Station, P. O. Box 7407, Washington, D. C. 20004 (1)

Texas A and M University, Radiation Biology Laboratory, Texas Engineering Experiment Station, College Station, Texas 77840 (2)

Texas Nuclear Corporation, ATTN: Director of Research, Box 9267 Allandale Station, Austin, Texas 78756 (1)

University of Rochester, Atomic Energy Project Library, P. O. Box 287, Station 3, Rochester, New York 14620 (1)

University of Southern California, Nuclear Physics Laboratory, University Park, Los Angeles, California 90007 (1)

Western Reserve University, Department of Radiology, Division of Radiation Biology, Cleveland, Ohio 44106 (1)

Mr. Lionel Zamore, 601 Brightwater Court, Brooklyn, New York 11235 (1)

FOREIGN

International Atomic Energy Agency, Kärntnerring 11, Vienna I. 1010, Austria (1)

European Atomic Energy Community, C. E. E. A., Library, 51 rue Belliard, Brussels 4, Belgium (1)

Dr. L. G. Lajtha, Paterson Laboratories, Christie Hospital and Holt Radium Institute, Manchester, England (1)

Dr. L. F. Lamerton, Biophysics Department, Institute of Cancer Research, Surrey Branch, Belmont, Sutton, Surrey, England (1)

National Lending Library for Science and Technology, Boston Spa, Yorkshire, England (1)

DIRECTORATE OF MEDICAL AND HEALTH SERVICES, FAF (FEDERAL ARMED FORCES), BONN, ERMEKELSTRASSE 27, WEST GERMANY (1)

Abteilung für Strahlenbiologie im Institut für Biophysik der Universität Bonn, 53 Bonn-Venusberg, Annaberger Weg 15, Federal Republic of Germany (2)

Prof. Dr. H. Langendorff, Direktor des Radiologischen Instituts der Universität, 78 Freiburg im Breisgau, Albertstrasse 23, Germany (1)

FOREIGN (continued)

Priv.-Doz. Dr. O. Messerschmidt, Radiologisches Institut der Universität, 78 Freiburg im Breisgau, Albertstrasse 23, Germany (1)  
Dr. Helmut Mitschrich, Sanitätsamt der Bundeswehr, 53 Bonn-Beuel, Zingsheimstrasse 5, Germany (2)  
Prof. Dr. F. Wachsmann, Gesellschaft für Strahlenforschung m.b.H., 8042 Neuherberg bei München, Institut für Strahlenschutz, Ingolstädter Landstrasse 1, München, Germany (1)  
Dr. M. Feldman, Section of Cell Biology, The Weizmann Institute of Science, Rehovoth, Israel (1)  
Dr. G. W. Barendsen, Radiobiological Institute TNO, Rijswijk, Netherlands (1)  
Dr. L. M. van Putten, Radiobiological Institute TNO, 151 Lance Kleiweg, Rijswijk 2 H, Netherlands (1)  
Puerto Rico Nuclear Center, ATTN: Reading Room, College Station, Mayaguez, Puerto Rico 00708 (2)  
Dr. H. Cottier, Pathological Institut der Universität, Bern, Switzerland (1)

## UNCLASSIFIED

Security Classification

## DOCUMENT CONTROL DATA - R &amp; D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Armed Forces Radiobiology Research Institute Defense Nuclear Agency Bethesda, Maryland 20014	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
	2b. GROUP N/A

## 3. REPORT TITLE

NOREPINEPHRINE EFFECTS ON EARLY POSTIRRADIATION PERFORMANCE DECREMENT  
IN THE MONKEY

## 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

## 5. AUTHOR(S) (First name, middle initial, last name)

J. E. Turns, T. F. Doyle and C. R. Curran

6. REPORT DATE November 1971	7a. TOTAL NO. OF PAGES 19	7b. NO. OF REFS 9
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)	
b. PROJECT NO. NWER XAXM	AFRRI SR71-16	
c. Task and Subtask C 906	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d. Work Unit 01		

## 10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Director Defense Nuclear Agency Washington, D. C. 20305
-------------------------	---

## 13. ABSTRACT

Monkeys, trained to perform a discrete trial, cued avoidance task, were used to measure the effectiveness of intravenously infused norepinephrine in preventing the hypotension and performance decrement which usually follows 3000- to 30,000-rad doses of radiation. After a 4000-rad dose of mixed gamma-neutron radiation, 10 animals were infused with norepinephrine at a rate designed to maintain mean arterial blood pressure at approximately 100 mm Hg; for comparison 10 control animals were infused with only isotonic saline after similar irradiation. Norepinephrine, although generally adequate for maintaining blood pressure, did not consistently improve performance during the first 30 minutes postirradiation.